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ABSTRACT

Learning is a complex operation that involves a several factors. In studying the learning process, both the characteristics of the learner and the conditions of instruction must be considered. This study examined some of the factors that may influence the learning of mathematics. In particular, it sought to identify relationships among mathematics anxiety, individual preferences for learning styles, and use of manipulative materials in learning activities. Reported in this paper are a brief literature review, research methods, results, and educational implications. Results of this study indicate that there is a significant relationship among mathematics anxiety, tactile-kinesthetic mode preference, and experiences with manipulative materials. (CW)

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Correlates of Mathematics Anxiety

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It is a well-known fact that learning is a complex operation which involves a number of factors. In study of the learning process, we must consider both characteristics of the learner and conditions of instruction. In our current technological world, we have become aware of the necessity of a solid mathematical background for all students. This study examined some factors which may influence the learning of mathematics. In particular, it sought to identify the relationships among mathematics anxiety, individual preferences for learning styles, and use of manipulative materials in learning activities.

Mathematics anxiety has been defined as an emotional and cognitive dread of mathematics (Williams, 1988). It has been found to have a negative effect on mathematics achievement and to cause mathematics avoidance (Clute, 1984; Fennema & Sherman, 1976; Tobias, 1987).

Learning style refers to the way in which the individual learner learns most effectively. One facet of learning style according to Dunn, Dunn and Price (1987) is perceptual preference. This refers to whether the student learns best by auditory, visual, tactile, or kinesthetic modes. Research has overwhelmingly found that students learn best when instructional mode matches their individual perceptual preference (Birely & Hoen, 1987; Carbo, 1984; Dunn & Bruno, 1985; Dunn & Dunn, 1987; Ross & Wright, 1987; Strother, 1985).

In recent months, the National Council of Teachers of Mathematics has published a far-reaching document entitled

Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989). Within this document are numerous references to teaching with manipulative materials. That is, each student should be allowed to experiment with concrete models of mathematics concepts. Through this active manipulation, it is believed that understanding will develop (NCTM, 1989). Research has found that the use of manipulative materials results in higher mathematics achievement (Kennedy, 1986; Suydam, 1984; Suydam, 1986; Williams, 1988).

Use of manipulative materials for mathematics instruction has also been found to reduce mathematics anxiety (Battista, 1986; Larson, 1983; Sherard, 1985; Williams, 1988). In addition, several writers have suggested that the roots of math anxiety are in teaching methods (Bulmahn & Young, 1982; Greenwood, 1984; Sovchik, Meconi & Steiner, 1981).

Hodges (1983) goes one step further and involves learning style, specifically perceptual preference. She suggests that poor mathematics achievers may be tactile or kinesthetic learners, that most mathematics instruction is auditory, and that this "mismatch" causes math anxiety which results in poor math achievement. While there is presently no empirical research to support this theory, it seems quite plausible. Thus, the purpose of the present study was to examine the relationship between mathematics anxiety, learning style (perceptual preference), and previous mathematics instructional activities (workbook and manipulative experiences).

Methods

Participants in this study were 76 preservice and inservice elementary teachers in a midwestern region. Since a large majority of the sample were women, gender was not considered. Each participant completed a three-part questionnaire designed to obtain information about their mathematics experiences, mathematics attitudes, and learning style preferences. Multiple regression analysis was then used to determine the relationships of the experience and learning style variables to math anxiety.

Part I of the questionnaire was designed by the researcher and contained questions about mathematics experiences in elementary school, junior high school, high school, and college. Subjects indicated whether their math classes at each level had included "much", "some", or "no" use of (1) workbook exercises and (2) manipulative materials. Scores were totaled for each instructional mode, yielding scores of 0-8 for workbook exercises and for manipulative materials.

Part II of the questionnaire contained four subtests from the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976). Students were asked to agree or disagree with positive and negative statements such as "I'm not the type to do well in math." No norms are available for the scales, but a higher total score is indicative of higher math anxiety (Fennema et al., 1981). Scores could range from 0 to 48.

Part III of the questionnaire consisted of the perceptual preference subtests of the Learning Style Inventory (Dunn, Dunn & Price, 1987). Scores were obtained for degree of auditory, visual, tactile, and kinesthetic preference. Reported test-retest reliabilities for these subtests range from .43 to .74. Raw scores were used in the analyses.

Results

Means and standard deviations of all variables are presented in Table 1. The correlation matrix for all variables is presented in Table 2. Because tactile and kinesthetic learning style scores were significantly related (suggesting multicollinearity), they were summed for the regression analysis, yielding a variable called tactile/kinesthetic preference. This combination has also been suggested by practitioners (Cruikshank & Sheffield, 1988).

Mathematics anxiety was then regressed on workbook experience, manipulative experience, auditory preference, visual preference, and tactile/kinesthetic preference. Results of a stepwise multiple regression (See Table 3) revealed that the variables significant in predicting mathematics anxiety were manipulative experience (*beta* = -0.260, *t* = -2.37, *p* < .05) and tactile/kinesthetic learning style (*beta* = 0.247, *t* = 2.25, *p* < .05). This model accounted for 10 percent of the variance in mathematics anxiety (Adjusted *R* squared = 0.10).

Educational Implications

These results support Hodges' (1983) theory that a combination of fewer manipulative experiences and stronger tactile/kinesthetic learning style preference contributes to math anxiety. Amount of workbook experience was not significantly related; nor was strength of auditory or visual learning style. Even though the perceptual preference scores are somewhat related, they are independent. Some students are more multisensory, and learn well through more than one perceptual mode (Dunn, Dunn & Price, 1987). Those students who expressed a stronger preference for tactile/kinesthetic mode (regardless of auditory or visual preference) were more math anxious.

The "mismatch" of student perceptual preference and instructional activity mode appears to contribute to math anxiety. Even though the literature contains results indicating that this "mismatch" results in poor achievement (e.g. Dunn & Dunn, 1987), no previous research results showed that math anxiety is involved. Results of the present study indicate that this interaction results in higher math anxiety.

This model accounts for only 10 percent of the variance in math anxiety, but it is a very important 10 percent. This is an area in which we can exercise some control. We can modify our mathematics teaching to include a variety of activities, so that concrete manipulative experiences are available for those students with tactile/kinesthetic learning styles who need them.

In light of the recommendations of the Standards (NCTM, 1989), we should be seeing increased use of manipulative materials at all levels of mathematics instruction. Research results such as these support the recommendations of the National Council of Teachers of Mathematics.

Results of this study indicate that there is a significant relationship among math anxiety, tactile-kinesthetic mode preference, and experiences with manipulative materials. It may be that much of the previously reported success of the use of manipulative materials to improve mathematics achievement (e.g. Suydam, 1986) was partially a result of reducing math anxiety by matching instruction to learning style preference. Further research should examine math achievement, math anxiety, perceptual preference, and classroom experiences to further explain this interaction. If we are to maximize mathematics achievement for students, we must fully understand the factors influencing their learning.

Table 1

Means and Standard Deviations of All Variables

Variable	Mean	Standard Deviation
Math Anxiety	8.487	8.208
Workbook Experience	6.645	1.794
Manipulative Experience	1.750	1.471
Auditory Preference	2.658	1.332
Visual Preference	1.605	0.896
Tactile/Kinesthetic Preference	3.829	1.331

N = 76

Table 2

Pearson Product-Moment Correlations for All Variables

	M.ANX	WKBK.	MANIP	AUDIT	VISU.	TAC/KIN
MATHANXIETY	1.000	.055	-.247	.056	-.030	.234
WORKBOOK EXP.	.055	1.000	.087	-.141	.036	-.004
MANIPULATIVE EXP.	-.247	.087	1.000	.071	.420	.053
AUDITORY PREF.	.056	-.141	.071	1.000	.187	.185
VISUAL PREF.	-.030	.036	.420	.187	1.000	.066
TACT./KIN. PREF.	.234	-.004	.053	.185	.066	1.000

N = 76

Table 3

Summary of Stepwise Multiple Regression Results for Math Anxiety

	INDEPENDENT VARIABLES	
	MANIP.EXP.	TAC./KIN.PREF.
Standardized Coefficients	-.260	.247
Regression Coefficients	-1.452*	1.526*
Standard Error	.613	.677

Constant = 5.186

Adjusted R^2 = .100*

* p<.01

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